DOCUMENT RESUME

ED 460 149 TM 033 623

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TITLE The Use of Technology by Teacher Education Faculty for Problem Solving and Higher Order Thinking.

PUB DATE 2001-11-00

NOTE 22p.; Paper presented as the Annual Meeting of the Mid-South Educational Research Association (30th, Little Rock, AR, November 14-16, 2001).

PUB TYPE Reports - Research (143) -- Speeches/Meeting Papers (150)

EDRS PRICE MF01/PC01 Plus Postage.

DESCRIPTORS *College Faculty; *Computer Uses in Education; *Educational Technology; Higher Education; Internet; Methods Courses; *Problem Solving; Teacher Education; *Teacher Educators; *Thinking Skills

IDENTIFIERS Arkansas

ABSTRACT

This study investigated college teachers' reported uses of instructional strategies that include realistic problem-solving based on technology competencies recommended by the International Society for Technology in Education and adopted by the National Council for the Accreditation of Teacher Education (NCATE). Data were collected from Arkansas faculty who taught methods courses at colleges of education accredited by the NCATE. Data from 125 faculty members (56% response rate) show that reporting faculty from Arkansas are integrating computers into their instruction in three main areas: (1) use of e-mail and the Internet; (2) use of the World Wide Web for problem solving; and (3) use of word processing to generate booklets, reports, and newsletters. The reported use of databases or spreadsheets was just above the median score of 2.0. Simulation software and spreadsheets for authentic problem solving were seldom or never used. (Contains 5 tables, 2 figures, and 23 references.) (Author/SLD)

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The Use of Technology by Teacher Education Faculty for Problem Solving and Higher Order Thinking

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Abstract

There is an increasing need for classroom teachers to plan instruction that is transferred from the school setting to the workplace. Employers have reported that new employees coming into their businesses, laboratories, and factories are often unable to initiate a strategy for solving day-to-day problems within the work environment. Since technology has become a pervasive influence in our lives, the use of these tools is commonplace for solving problems and reaching goals. The International Society for Technology in Education (ISTE), developed specific competencies for teachers and the use of the computer as an instructional tool. These competencies have been adopted by the National Council for the Accreditation of Teacher Education (NCATE) as a qualifying standard for teacher education programs. For professional schools to earn national accreditation, NCATE prescribes indicators as evidence for a quality teacher-training program. Included in these indicators is the use of computers within the curriculum. The purpose of this study was to investigate reported uses of instructional strategies that include realistic problem-solving based on technology competencies recommended by the ISTE and adopted by NCATE. Data were collected from faculty who taught methods courses in colleges of education accredited by NCATE. The data showed that reporting faculty from Arkansas are integrating computers in their instruction in three main areas, (1) use of email and the Internet, (2) use of WWW for problem-solving, and (3) use of word processing to generate booklets, reports, and newsletters. Faculty's reported use of database or spreadsheets was just above the median score of 2.0. Use of simulation software and spreadsheets for authentic problem-solving was seldom or never used.

Introduction

Studies by the U.S. Department of Education (OTA, 1995) have reported that students are exiting their public school careers without the skills needed to be competitive in a technologically-oriented society. They lack the ability to "think through" the instructions for using a new software package. They are unable to initiate problem-solving within a collaborative group environment. Goals 2000, the federal initiative for raising the educational standards for elementary and secondary schools, identified the need for improved communication skills, efficient and diverse access to information, use of higher- order thinking, enhanced problem-solving skills, and self-directed learning (Bitter, Thomas, Knezek, Friske, Taylor, Wiebe, & Kelly, 1997). Although these are not specifically technology skills, Bitter et al. (1997) suggested that technology could be used to effectively reach these goals.

The International Society for Technology in Education (ISTE), developed specific competencies for teachers and the use of the computer as an instructional tool. These competencies have been adopted by NCATE (National Council for the Accreditation of Teacher Education, 1996, 1997) as a qualifying standard for teacher education programs. For professional schools to earn national accreditation, NCATE prescribes indicators as evidence for a quality teacher-training program. Included in these indicators is the use of computers within the curriculum. Arthur Wise, President of NCATE, reports that computers and related technologies affect future employment needs, methods for gathering and evaluating information, and the use of problem solving skills in the workplace (National Council for Accreditation of Teacher Education, 1997). In order to keep teacher preparation aligned with changes in technology, a task force on technology and teacher education, commissioned by NCATE, examined the issues that affect implementation of technology in teacher education. The goal of the task force was to

ensure that colleges use a comprehensive, multifaceted approach for implementing technology within teacher preparation. One outcome from their meetings was the adoption of the *Recommended Foundations in Technology for All Teachers* (International Society for Technology in Education, 1999). These Foundations under-gird the more recent NCATE standards for measuring technology competence: the *National Educational Technology Standards and Performance Indicators* (International Society for Technology in Education, 2001). The Indicators recommend that all candidates for teacher certification should meet criteria related to three areas of technology: (1) basic computer operation, (2) personal and professional use of technology, and (3) application of technology for instruction. From these three criteria, six Standards and Performance Indicators for teachers were developed (Table 1).

Table 1 ISTE National Educational Technology Standards and Performance Indicators (NETS). [Available online: http://cnets.iste.org/teachstand.html]

I. Technology Operations and Concepts. Teachers demonstrate a sound understanding of technology operations and concepts.
II. Planning and Designing Learning Environments and Experiences. Teachers plan and design effective learning environments and experiences supported by technology.
III. Teaching, Learning, and the Curriculum. Teachers implement curriculum plans that include methods and strategies for applying technology to maximize student learning.
IV. Assessment and Evaluation. Teachers apply technology to facilitate a variety of effective assessment and evaluation strategies.
V. Productivity and Professional Practice. Teachers use technology to enhance their professional practice.
VI. Social, Ethical, Legal, and Human Issues. Teachers understand the social, ethical, legal, and human issues surrounding the use of technology in PK-12 schools and apply those principles in practice.

According to Wise (NCATE, 1997), teacher education faculty consider computers and other technologies as a separate content area, one to be taught by faculty with expertise as the computer or media instructor. Teachers-in-training often take these courses late in their academic program (Vagle cited in Galloway & Blohm, 1997) and rarely are required to apply the use of technology in methods courses. Thus, the purpose for this study was to investigate whether teacher education faculty are using strategies that develop higher-order thinking for realistic problem-solving that are aligned with the technology competencies recommended by ISTE and adopted by NCATE. Two questions were used to frame the investigation. First, to what extent do faculty report the use of instructional strategies based on performance indicators as stated in the National Educational Technology Standards for Teachers (International Society for Technology in Education, 2001). Second, what strategies are faculty using that support learning for realistic problem-solving that will transfer to the workplace?

Literature Review

Transfer to the Workplace

The question is often asked, "will instructional strategies used in our schools transfer to the work environment?" If we support Goodlad's position that one of the purposes for schools is in the production of good citizens (1994), then we are concerned about developing computer skills that are usable within diverse problem situations. Based on this premise, NCATE standards recommend that teachers demonstrate knowledge of uses of computers in business, industry, and society.

In the early 1990's, Lowther and Morrison (1998) warned that computers were not being used in school classrooms as they would be used in the workplace. Drill-and-practice software, word processing, and games were the most common applications for student use. Using a

national sample, NCES reported 25% of high school seniors use the computer for solving math problems, processing data, or computer programming (National Center for Education Statistics, 2000). One reason for lower use of problem-solving activities may be the infrequent use of planned instructional events that include problem-solving strategies. Becker (1999) reported that teachers use technology primarily for professional productivity such as record keeping or for information-gathering rather than instructional strategies to include problem-solving. To develop problem solving skills, teachers should design lessons that use spreadsheets and databases to analyze data, show comparisons, and see relationships between concepts. The strategies for using this type of software are based on collaborative, problem-based learning that is more closely identified with workplace applications.

Davis (1997) distributed surveys to 300 perspective employers who, over a period of time, visited the Cornell University campus for the purpose of recruiting new graduates. The results of his survey showed that employers are looking for people who are computer literate. Basic skills in word processing, database, and spreadsheet applications are important, but beyond familiarity with software packages, they are looking for people who can solve problems, think logically, and communicate clearly. Along with computer literacy, they are looking for employees who can, "...grasp concepts that can be applied to many situations across programs" (p. 77).

The University of Arkansas at Little Rock surveyed information technology companies in Arkansas. The study was conducted for the purpose of determining human resource needs for businesses with technology-based services within the state. The results showed "..... fewer than 500 Arkansans will be qualified to fill the job openings that high-tech companies anticipate having this year" (as cited in University of Arkansas at Little Rock, [On-line], 1999). Teachers have a responsibility to teach problem-solving within changing contexts. Students need computer skills that will transfer from problem to problem and from school to the workplace.

Problem solving and Technology

Knowledge is a personal product for each individual. Situated-learning theory suggests

that knowledge encoded while learners are engaged in real-world, authentic activities is more durable. (Brown, Collins, & Duguid, 1989; Choi & Hannafin, 1995). We make meaning of new information based on what we already know. Learning is also a process of enculturation. Encounters with new information, objects, and activities mean different things to different people. When learners are engaged in an activity that is simulated to closely represent a realistic event, they use cultural knowledge to make meaning of what they are learning. The research for authentic learning activities (Cognition and Technology Group at Vanderbilt, 1990) has shown that learning is enhanced through the use of technology-based lessons situated within a realistic context.

Authentic data and ill-defined problems. The Office of Educational Research and Improvement (Means & Olson, 1995) has sought to discover the effects of technology for higher-order learning. This is accomplished as classrooms are restructured to accommodate student-centered instructional strategies that use open-ended problems for developing higher levels of learning. Studies in learning and cognition (Chi & Ceci, 1987) have found that children learn at higher levels and transfer skills to new problems when knowledge is gained from everyday experiences. Learning within context is based on the use of authentic data and ill-defined problems. While authentic data need not be manipulated through the use of technology, Means and Olson (1995) found that teachers report several distinctive areas in which technology had a strong effect. First, for those schools connected to the Internet, there was a considerable increase in the use of outside resources.

In addition, through case-study analysis, it was learned that the quality of students' projects and artifacts greatly improved when using technology. For example, working in pairs, students examined and reexamined word processing documents through the use of the editor and spellchecker. They were able to use the computer in a realistic application to produce a document, and they were engaged in dialog and collaboration, which contributed to improved learning. Students were able to talk about the variables in the problem just as they would in a real-world work environment. Along with to collaborative dialog, students were

required to manipulate data using spreadsheets and databases. Teachers reported a deeper understanding of complex tasks and attributed this to the use of data manipulation on the computer. Through the use of the software for solving problems, technical skills improved also, thus self-esteem increased.

Other research (Thorsen & Barr, 1997) has been reported in support of productivity software for instruction. Databases should be used for sorting, making queries, and organizing information. Spreadsheets are valuable tools for estimation and what-if thinking. Presentation software can be used to help students sift through large quantities of information, select what is important, and present a logical summary of the information (Davidson, Deuser, & Sternberg, 1994). The application of these tools is linked with NCATE standards that recommend the use of computers for problem-solving and data collection (National Council for Accreditation of Teacher Education, 1996).

Information Processing and Problem-solving. The World Wide Web (WWW) and web browser software can be used to develop cognitive processes that connect new information with prior knowledge. Because of the magnitude of the Web and the unique capabilities of hypermedia, students are able to investigate many sources of information. The ease in which students can follow a variety of search paths has the advantage of relating new information to the differences in students' prior knowledge. Kafai and Bates (1997) observed elementary students' high motivation as they searched the web to gain information literacy skills. They also developed critical thinking skills as they assessed the usefulness of a variety of sites. Through their evaluations, they determined if a particular site should be included in their annotated bibliography of sites to be published on the web for other students and teachers. Here is an example of an authentic problem that uses technology for linking prior knowledge to many sources of new information.

There is a much evidence to support the use of computers and related technologies for higher level thinking and problem solving. Integration strategies are needed for instruction that develop thinking processes that will prepare teachers as they, in turn, prepare children for the

future academic endeavors, the marketplace, or the laboratory. Teacher education faculty have an important obligation to model the use of technology within their own college classrooms.

Method

Sample

The method used for this study was to survey a sample of teacher educators from the state of Arkansas. These were selected from colleges affiliated with the National Council for Accreditation of Teacher Education (NCATE). According to studies by the Milken Exchange on Education Technology (Moursund & Bielefeldt, 1999), NCATE member institutions tend to report more instructional technology integrated into the regular classroom instruction than non-NCATE institutions. A total of 14 colleges in Arkansas hold full accreditation and 2 are accredited with probation. Purposive sampling was used to identify instructors within certain disciplines. Only teacher educators with a specialty in secondary methods for foreign languages, English, science, math, or history, and educators who specialized in elementary teaching methods for classroom management, reading, language arts, science, math. or social studies were selected for the study.

Survey Instrument

Survey Items were developed by the researcher based on the review of the literature (Barron & Goldman, 1994; Bitter et al., 1997; Jonassen, 1995, 1996; Means & Olson, 1995; Lowther & Morrison, 1998; Rakes, 1996; U.S. Office of Technology Assessment, 1995), recommended standards developed by the International Society of Technology in Education (1997, 1999), and NCATE recommendations for performance based standards for teacher education programs (National Council for Accreditation for Teacher Education, 1996, 1997). In addition, the survey was pilot-tested by selected faculty from two universities. Their recommendations were used to refine the questions so that data would be useful for answering the research questions, and to prepare a concise survey, which would increase the probability for a high response rate.

The questionnaire was divided into four sections. Section I contained demographic questions such as age, years of service, gender, and specialty area. Sections II and III contained items that were designed to measure personal use of computers and related devices.

Section IV contained items designed to measure the use of technology for realistic problem-solving experiences. Respondents were asked to rate themselves on the frequency of use for each strategy by marking 1, 2, 3, or 4 where 1 = never and 4 = frequently. In Table 2, survey items have been aligned with NETS performance indicators (Table 1).

Table 2 Survey items related to teaching strategies used by methods faculty.

Survey item	NETS Standards Category\ (See Table 1)
a. word processing to generate booklets, reports, or newsletters related to students' subject area	III, IV, V
b. database applications for comparing and contrasting a variety of concepts related to subjects they plan to teach	I, III, IV, V,
c. database or spreadsheet application to organize large amounts of information	I, III, IV, V
d. spreadsheets for making predictions and generating more than one solution to a problem	III, IV
e. Internet to locate a variety of resources to solve an open-ended problem.	II, III, IV, V
f. Internet and/or email to locate information about the teaching profession.	III, IV, V, VI
g. use of multimedia software such as Hyperstudio or KidPix for projects related to students' content area	I, II, III, IV, V
h. projects that use scanners or digital cameras	I, V
i. electronic portfolios or webpages as a method for assessment and students' self-evaluation	I,
j student generated lesson plans that integrate the use of the computer into their teaching strategies	II, III
k. use of software for drill-and-practice within students' subject areas	II, III

Table 2 Continued.....

l. use of simulation software that allows students to have real-world experiences not possible within the regular classroom environment.	II, III
m. use of tutorial software that teaches concepts linked with students' subject area	II, III
n. observation experiences with inservice teachers who are recognized for innovative uses of technology	III, IV, VI
o. field experiences in which students must plan and present a lesson in a school with inservice teachers.	III, IV, VI
p. lessons that include awareness of computer-uses in business, industry, and society	III, VI

A total of 269 surveys were mailed to faculty at their college address. Mail-outs included a cover letter explaining the purpose of the survey and the importance of the study. A total of 125 usable surveys were returned. The response rate was calculated based on the number of usable responses divided by the valid number of mail-outs for a response rate of 56%.

Data Analysis

SPSS was used to calculate means, standard deviations and frequencies of reported use for each of the individual survey items. Pearson correlation coefficients were used as an index to determine the strength and direction of relationships among the reported scores for use of strategies for higher level thinking and software applications such as word processing, database, and spreadsheets.

Results

Demographics

Over half the respondents were 50 years of age or older (n=73), with 33 of the respondents indicating age 40-49. Thus, almost 85% of the teacher education faculty who responded to the survey were over age 40. There was nearly an equal number of male and female

(male, n=60; female, n=65) respondents. Most of the respondents held tenure-track positions (n=100), while a smaller number indicated nontenure-track positions (n=25).

Pearson Correlation Coefficients.

Pearson correlation coefficients showed a strong positive relationship between the use of database and spreadsheet applications and the use of problem-solving activities such as making comparisons and organizing large amount of information. There was a significant relationship between the use of word processing for written reports and the use of strategies for making comparisons. Though not as strong, there was also a significant relationship between use of word processing and the use of activities for organizing information. Notice in Table 3, however, there was not a relationship between the use of spreadsheets for making predictions and the use of word processing for generating written booklets.

Table 3 Pearson Correlation Coefficients for Items Related to Use of Software with Problem-solving Activities

Strategy from Survey Item *Use of .....*	database spreadsheet for comparisons	database spreadsheet for organizing	spreadsheet for predicting
word processing for generating booklets	.446**	.296**	.170
database/spreadsheet comparisons	---	.556**	.428**
spreadsheet/database for organizing	---	---	.641**

** $p = .01$, $N = 125$

In survey items related to use of technology in teaching, respondents were asked to indicate, on a Likert scale (1=never to 4=frequently), their frequency of use for a particular strategy. The data show that faculty are using the Internet for gathering information and open-ended problem solving. Faculty reported frequent use of Internet and email, use of World Wide Web for problem-solving, and word processing for generating books and reports. However, the reported use of database and spreadsheets applications for instructional activities was much less frequent when compared to reported use of Internet and word processing. The reported use for each of the strategies can be seen in Table 4. Most frequently used strategies were ranked by the mean score. Strategies using the Internet and word processing have means above 3.0. Less frequently used strategies were reported with means below 2.0.

Table 4 Survey Items: *How You Teach With Technology*

Indicate frequency of assignments using strategies in survey items (Scaled items 1 = none or never, 2 = moderate to none, 3 = moderate to high, 4 = high or frequently) N = 125	M	SD
Internet and /or email to locate information about the teaching profession	3.51	.79
Internet to locate a variety of resources to solve an open-ended problem	3.40	.77
Word processing to generate booklets, reports, or newsletters related to Students' subject area	3.22	1.02
Database or spreadsheet program to organize large amounts of information	2.16	1.05
Database program for comparing and contrasting a variety of concepts related to subjects they plan to teach	2.03	.99
Electronic portfolios or webpages as a method for assessment and students' self-evaluation	1.94	.97
Projects that use scanners or digital cameras	1.92	.91
Use of simulation software that allow students to have real-world experiences not possible within the regular classroom environment	1.77	.87
Spreadsheets for making predictions and generating more than one solution to a problem	1.63	.83
Multimedia software such as Hyperstudio . . . for projects related to students' content area	1.62	.84

Scores were ranked from 1 to 4 with 1 indicating none or never and 4 indicating high or frequently

Table 5 shows the percentage of use for problem solving strategies by respondents. N = 125

Survey Item	1 = never use	2 = moderate use	3 = moderate to frequent use	4 = frequently use
Internet to locate information about the teaching profession	3%	9%	22%	66%
Word processing for student-generated products	9%	17%	18%	57%
Internet to solve open-ended problem	2%	13%	29%	57%
Spreadsheet or database to organize information	34%	29%	23%	14%
Database for comparing and contrasting concepts	36%	36%	17%	11%
Electronic portfolios and webpages for assessment	40%	35%	15%	10%
Projects that use scanners or digital cameras	38%	38%	16%	7%
Multimedia software such as Hyperstudio . . . for projects related to students' content area	58%	28%	10%	5%
Simulation software for real-world experiences	48%	33%	14%	5%
Spreadsheets for predictions and alternate solutions	56%	29%	11%	4%

Table 5 shows the percentages for reported uses of problem-solving strategies included in the survey. The use of Internet for information gathering and word processing for student projects are the most frequently used computer functions. Figures showing a comparison of most frequently and least frequently used instructional strategies are included in Appendix I.

Conclusions

Research in learning and cognition has presented evidence in support of open-ended and authentic problems to improve problem-solving skills. Representatives from business and industry express concerns about new employees who are unable to solve problems independently. As seen in the above results, the data show that reporting faculty from this sample are integrating computers into their instruction within three main areas, (1) use of email and Internet, (2) use of World Wide Web for solving open-ended problems, and (3) use of word processing to generate booklets, reports, and newsletters. One purpose for this study was to

investigate frequency in the use of strategies that develop problem-solving skills. Based on the reported use by all respondents, strategies for comparing and contrasting concepts and for making predictions was infrequent. Those who did report a moderate use for problem-solving strategies included the use of database and spreadsheet applications. However, most of the faculty reported *never* using spreadsheets for making predictions or using multimedia software for projects related to students' content area. The data also revealed that there were no strong correlations between the use of spreadsheet applications for making predictions and word processing. This would suggest that the powerful capability of spreadsheets for designing "what-if" activities that extend beyond simple data collection might be unknown to the faculty. In addition, without a correlation between word processing and spreadsheets for making predictions, it is unlikely that faculty are requiring students to report outcomes, conclusions, and predictions in a narrative report.

Even though there was frequent use of Internet and email reported, there was little evidence from this sample to suggest that students were using Internet resources for culminating activities that extend beyond data collection. There was also little evidence to suggest that instruction required students to draw conclusions and express these in written narratives. By using such tools as database and spreadsheets, students are better able to develop problem-solving skills by identifying common elements from prior knowledge and relate these to the new information.

The data from this study showed a low use of multimedia software such as Hyperstudio® or Kidpix®. Thus, it is unlikely that faculty from this sample are using technology-related activities that support learners as they generate cognitive connections between new concepts and previously learned concepts and principles. However, the data showed many methods instructors

responded with frequent use of the web for solving open-ended problems. In addition, two-thirds of all respondents reported frequent use of Internet or email to locate information about the teaching profession. This is a significant increase over usage reported in an earlier study (ITRC, 1998). Although increased use for this strategy is a positive trend that complies with ISTE recommendations, it is unclear from this study, if faculty are able to make the distinction among various Internet resources for online collaboration, discussion threads, listservs, and email compared to less personalized resources available through websites. For example, information gathered from a website may have very different value from information received in a personal email sent by an online expert. Learning about these kinds of distinctions are important topics and should be considered when departments of teacher education are planning sessions for faculty development. Additional data would need to be collected to determine if faculty are able to identify the benefits for the various Internet resources.

The sample of faculty from one state limited the conclusions drawn from this study. Self-reported data from a national sample would better generalize to the population of methods instructors in schools of education. In order to gain more information pertaining to the reasons for lack of use, possible barriers, and lack of access, the study should be extended to include interviews with open-ended questions. Focus groups that represent a sample from both high and low level users of technology should be selected. In addition, statistical analysis that examines relationships between faculty characteristics and reported uses for technology may provide useful information when planning for professional development.

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Appendix I

Figure 1 Comparison of the most frequently used strategies. (N = 125)

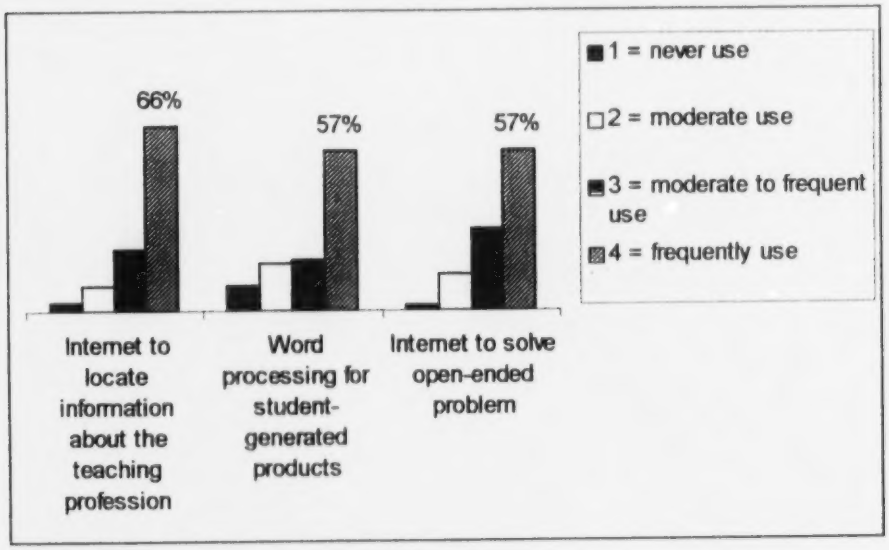
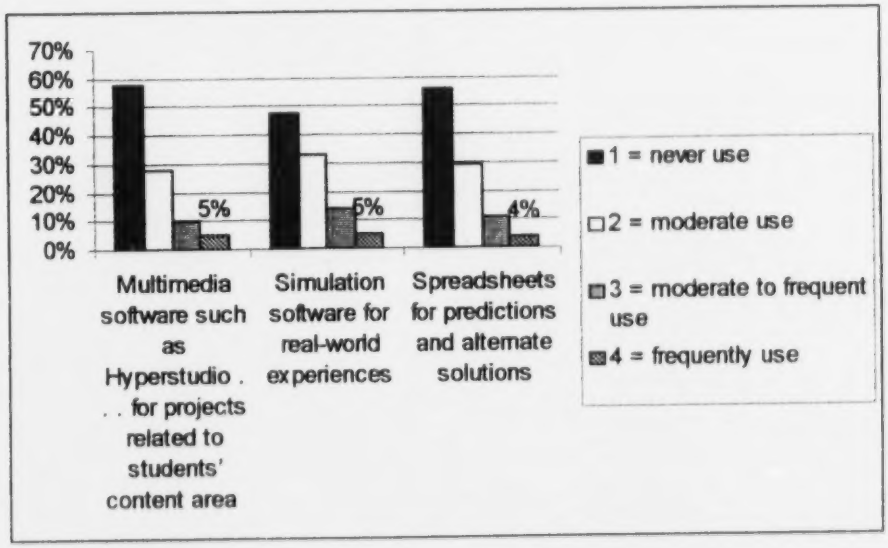


Figure 2 Comparison of the least frequently used strategies. (N = 125)



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